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A CONTRIBUTION TO THE PETROGRAPHY OF THE SOUTH SEA ISLANDS

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Communicated February 18, 1918

A brief statement of the geological structure and general character of the rocks of the Islands of Tahiti, Moorea, and the Society Group has been given in a previous number of the Proceedings of the National Academy, from which it appears that each island is a profoundly eroded volcano, consisting mainly of basaltic lavas rich in olivine and augite, with inconspicuous feldspar, and that at five of the volcanic islands there are trachytic or phonolitic lavas which have been erupted late in the period of activity. In two volcanoes erosion has exposed coarsely crystallized cores of gabbroic and theralitic rocks with peridotites, and in one case syenites and nephelite-syenites as the latest eruptions.

Nearly seventy years ago J. D. Dana called attention to these syenitic rocks on Tahiti, and remarked that they were only a feldspathic variety of the same igneous rocks that constitute the island. Eight years ago Lacroix published a description of the alkalic rocks of Tahiti with chemical analyses, laying particular stress on the syenitic varieties and on the haüynophyres, with certain limburgitic lavas, but noting the fact that the preponderant rocks of the islands are basalts rich in olivine. From the emphasis laid upon the alkalic rocks, one gets the impression that they are more abundant than is actually the case. However, their theoretical importance has not been exaggerated. More recently Marshall has analysed and described phonolitic rocks from the Leeward Islands and from Raratonga, Cooks Islands, and has analyzed several rocks from Tahiti. So there are already a number of chemical analyses of igneous rocks from the islands of this part of the Pacific Ocean.

In order to extend the investigation somewhat further, and to include the more common varieties of basalt so as to give a clearer idea of the prevailing rocks of the islands, chemical analyses have been made of rocks from different islands of the Georgian and Society groups. These have been placed in sequence in one table for comparison with one another, and to show the resemblances among the various lavas of these islands. The analyses have been obtained in part with the aid of grants 192 and 203, from the Bache Fund of the Academy. That is, those by Professor Foote and by Dr. Washington. The microscopical study has also been carried on with the aid of these grants. As the specimens collected represent over 550 rocks from seven volcanic islands, it is only possible in this preliminary statement to notice particularly the 30 specimens whose analyses are published for the first time in the accompanying table, with some observations concerning their relations to the rocks with which they are associated.

The rocks of Tahiti are almost wholly basalts rich in olivine and augite, with few or no phenocrysts of feldspar. They differ from one another somewhat in the size and abundance of the phenocrysts of olivine and augite. At one extreme are basalts with abundant phenocrysts; at the other are basalts without any, but with ill-defined spots which are lighter colored than the body of the rock. Such basalts form large flows often in superposition, as at Point Tapahi on the north coast where a strongly porphyritic basalt forms the lower layer or flow, at the water's edge, and a non-porphyritic spotted basalt forms the upper flow. The upper rock has been analyzed, no. 19 in the table, and proves to be a limburgose, bordering on camptonose, with 8.5% of normative nephelite. The light-colored spots in the rock are probably due to areas of altered nephelite, or to analcite. The rock is aphanitic, and under the microscope is seen to be holocrystalline; composed of augite, magnetite, ilmenite, and olivine in a matrix of plagioclase with nephelite or analcite. Similar basalt forms a massive flow and has been quarried near Papeete. A strongly porphyritic basalt rich in olivine, like the rock at Point Tapahi, is in place on the road farther west. Its analysis, no. 27, shows it to be uvaldose, a highly mafic rock without normative nephelite. It is holocrystalline; the groundmass crowded with augite, olivine and magnetite, with quite subordinate amount of plagioclase feldspar. It is in fact limburgite. These two varieties of basalt are common throughout the islands visited, a very similar rock, no. 28, having been analyzed from the west coast of Raiatea. It is, however, somewhat more coarsely crystalline, the individual crystals being distinctly visible microscopically. Some of the plagioclase feldspars have outer zones of alkalic feldspar, probably soda-orthoclase.

A limburgitic basalt which appears to be a large massive body, exposed in Fautaua Valley on the trail above the waterfall, is a gray rock with small miarolitic cavities. It is holocrystalline and consists of abundant subhedral, violet-tinted augites, of variable sizes, with much colorless olivine, subhedral magnetite, in part dendritic, and areas of poikilitic plagioclase, with patches where the matrix is alkalic feldspar and analcite. The chemical analysis is no. 26 and the norm is relatively high in alkalic feldspar, low in anorthite, with 7% of normative nephelite. There is 5% of apatite which appears as thin acicular prisms. A corresponding amount of apatite occurs in a theralite from Taiarapu, analysis 22. Another basalt from Fautaua Valley is found in boulders in the stream near the ridge above the falls. Its chemical composition, no. 25, is similar to the rock just described, no. 26, but it appears somewhat differently under the microscope. It consists chiefly of violet-tinted augite, with abundant colorless olivine, and magnetite, and clusters of rods of ilmenite, with minute needles of augite. Between these is a small amount of colorless matrix which is in part plagioclase feldspar. The norm shows a small amount of anorthite, 19% of feldspathoids, and no alkalic feldspar. There is about 2% of calcium orthosilicate which does not appear as melilite in the mode, and is probably incorporated in the mafic minerals. This is also a limburgite.

A basalt still richer in olivine, of the utmost freshness occurs on the east side of Raiatea, its analysis, no. 24, shows 23.97% of magnesia, or nearly 45% of normative olivine. It is a most beautiful chrysophyre, or limburgite, with a holocrystalline groundmass crowded with microscopic augites, olivines, magnetite and subordinate plagioclase. On the Island of Moorea a limburgite with similar chemical composition, no. 23, was found in large blocks, but not in place. It is more coarsely crystallized and resembles a peridotite megascopically. It is perfectly fresh and has a scant matrix of microscopic plagioclase. The norms of these highly olivinitic basalts do not contain normative nephelite, but contain normative hypersthene. The silica is comparatively high for the amount of alumina, which is low; the magnesia being abnormally high.

In the central core of the dissected volcano of Tahiti, and in that of Taiarapu, there are coarse-grained theralites which are chemically similar to the non-porphyritic basalt forming the upper flow at Point Tapahi, Tahiti. Their analyses are nos. 20, 21, and 22. They are limburgose and limburgose-etindose, and are characterized by notable amounts of normative nephelite, which is also modal. In no. 22 there is also normative leucite, which, however, does not appear in the mode, which contains considerable biotite. The theralite from Vaitipihia, Tautira Valley, Taiarapu, no. 20, is rich in augite, brown amphibole and biotite, with subordinate plagioclase and nephelite. That from Maroto River, in the Papenoo Valley, Tahiti, no. 21, is very much like no. 20, but has less amphibole and a slightly different texture. The other theralite from Vaitipihia, no. 22, contains large brown amphiboles, surrounded by brown biotite, with little augite, and much apatite. The chemical compositions of coarse-grained rocks of unusual mineral composition from the core of Taiarapu are given in nos. 29 and 30. The first is a narrow vein of pyroxenic rock traversing basalt. It consists almost wholly of slender dendritic crystals of augite in a microscopically fine-grained matrix. The norm has 45% of diopside, 5% of olivine, 26% of anorthite and small amounts of normative nephelite and leucite. The second rock, no. 30, is a peridotite composed of augite, olivine, brown hornblende, iron ores and pyrite, with very small amounts of feldspathic minerals; the norm containing a little normative nephelite and leucite.

The analyses of other basalts from these islands are given in nos. 14 to 18 in the table. They are camptonose and camptonose-auvergnose, and are from Moorea, Huahine, Tahaa and Bora Bora. The basalt from Tahaa, no. 14, is rather coarse-grained and forms a dike near the coast on Rei Point. It is the rock used for ballast by small boats in this region, and may be found in the ports on various islands, and is probably the rock called granite by early explorers. It is a dolerite and looks like a fine-grained gabbro. It is rich in olivine and its norm contains a small amount of nephelite. The basalt from Bora Bora, no. 15, is porphyritic, very rich in olivine, and has nearly the same chemical composition as no. 14. The columnar basalt from Moorea, no. 17, and the basalt from Huahine, no. 16, are very similar chemically, while the basalt from the base of Mauratapu on Huahine, no. 18, is lower in magnesia and higher in lime and alumina. These basalts do not contain normative nephelite, and differ from one another somewhat in texture.

From the foregoing it is seen that the basaltic rocks of this region, and their coarsely crystallized phases, which occur in the cores of the volcanoes of Tahiti and Taiarapu, are normatively nephelite-bearing, except some of the highly olivinitic varieties, and some others. Nephelite is visibly present in the modes of the coarsely crystallized rocks, and is possibly present in microscopic crystals in many of the fine-grained and aphanitic basalts, though it is probable that it is represented by analcite in some instances, either as a primary mineral, or as a product of alteration.

The trachytic and phonolitic lavas, which are known to occur at five of the volcanic islands visited, are very similar to one another chemically, as is shown by analyses 1 to 8. The rocks from Nutae, no. 3, and Point Riri, no. 6 on Taiarapu, are light gray and but slightly porphyritic, with fissile parting and satin lustre. The first occurs as boulders on the beach associated with haüynophyre. The second is in place, and is exposed in large blocks. Each contains a small amount of normative nephelite, and a little that can be identified as modal nephelite, so that the rocks are properly nephelite-bearing trachytes, rather than phonolites. They have a microtrachytic texture, the first one containing small scattered phenocrysts of alkalic feldspar. Similar rocks occur on Huahine, nos. 1 and 5. They are darker colored and more fissile. Microscopically they appear to contain abundant minute crystals of nephelite, and to be characteristic phonolites. However, most of the rectangular crystals are alkalic feldspars and not nephelite, as their index of refraction shows. These rocks also are nephelite-bearing trachytes and not properly phonolites. The same is true of similar massive rocks from Raiatea, the fissile mass forming the top of Mount Tapioi, no. 4, and the rock of the sugar-loaf dome on the east side of the island, no. 2. These rocks are nephelite-bearing trachytes with small amounts of nephelite. The rock from the top of Mount Tapioi contains minute crystals of what appear to be sodalite scattered through the feldspars. Similar nephelite-bearing trachytes with less nephelite form large bodies of rock on Moorea, the analysis of one of them being given in no. 8.

Some varieties of these trachytic rocks, occurring on Taiarapu, contain haüynite in small crystals, and 12% of normative nephelite and are properly phonolites. Analysis 7 is from such a rock. One variety, no. 11, from the beach at Tautira consists of alkalic feldspar and andesine, with some nephelite and sodalite, and contains abundant small phenocrysts of brown hornblende, with much titanite and few augites and micas. Chemically it is very similar to a tephritic trachyte from Bauza, Columbreta, described by Becke. Its symbol in the Quantitative System of Classification shows that it is transitional. In the qualitative system it corresponds to a nephelite-latite, or

Table of Chemical Analyses and Norms of Lavas from South Pacific Islands

	1	2	3	4	5	6	7	8	9	10
SiO_2	61.98	62.20	61.07	62.44	61.90	60.48	58.84	57.61	56.33	56.68
Al_2O_3	18.72	17.85	17.77	18.87	18.37	19.35	20.30	16.47	18.44	18.73
Fe_2O_3	2.34	2.31	2.18	1.87	2.46	2.34	2.74	2.84	5.89	4.34
FeO	1.17	0.95	1.49	0.87	0.66	1.19	0.64	4.72	2.60	0.94
MgO	0.39	0.83	0.88	0.62	0.46	0.75	0.60	0.86	1.04	1.97
CaO	1.09	1.33	1.30	1.35	0.58	1.68	1.66	2.61	2.70	3.60
Na_2O	7.16	6.74	6.80	7.29	7.95	6.50	7.48	5.06	4.34	5.64
K_2O	5.66	5.80	5.57	5.66	5.36	5.90	5.72	5.97	4.82	3.85
H_2O+	1.05	0.95	1.71	0.32	1.52	0.87	0.68	1.43	1.85	1.71
H_2O-	0.42	0.36	0.11	0.17	0.61	0.25	0.31	0.35	0.52	0.80
TiO_2	0.26	0.57	0.94	0.62	0.20	0.72	0.72	0.51	0.88	0.91
ZrO_2			0.12					0.00		
CO_2			none					0.03		
P_2O_5	0.03	0.14	tr.	0.09	0.01	0.16	0.13	0.42	0.61	0.74
Cl								0.08		
F								n. f.		
S			none					0.04		
Cr_2O_3	tr.	tr.		tr.	tr.	tr.	0.02	0.00	0.00	tr.
MnO	0.30	0.24	0.05	0.21	0.26	0.14	0.12	1.39	0.11	0.33
BaO			none			0.14	0.07	1.02		
SrO							0.00	0.01		
	100.57	100.27	99.99	100.38	100.34	100.47	100.03	100.42	100.13	100.24

Norms

	1	2	3	4	5	6	7	8	9	10
Q									7.02	0.60
or	33.92	34.47	33.36	33.92	31.69	35.03	33.92	35.58	28.36	22.80
ab	51.87	52.92	50.83	51.87	52.40	46.63	41.39	40.35	36.68	47.68
an	1.67	1.11	1.39	1.67		6.12	4.73	4.45	9.73	13.07
ne	4.83	2.27	3.69	5.40	6.53	4.54	11.93	1.42		
C									2.45	0.41
Z		0.18								
ac					2.31					
di	2.65	3.67	3.89	3.34	2.48	1.08	2.16	4.80		
wo	0.23									
hy									2.60	4.90
ol		0.28	0.28			0.98	0.35	5.81		
mt	3.25	2.32	2.09	1.62	2.31	2.32	0.23	4.18	6.03	1.62
il	0.61	1.06	1.82	1.22	0.46	1.37	1.37	0.91	1.67	1.67
hm		0.64	0.80	0.80	0.16	0.64	2.56		1.76	3.20
ap		0.34		0.34		0.34	0.34	1.01	1.34	1.68
etc	1.50	1.31	1.87	0.49	2.14	1.26	1.08	1.96	2.37	2.51
	100.53	100.39	100.20	100.67	100.49	100.31	100.06	100.47	100.01	100.14

1. I. 5.1. (3)4. phlegrose-nordmarkose, nephelite-trachyte, road S. of Mt. Paeo, Huahine.
2. I′. 5.1. (3)4. phlegrose-nordmarkose, nephelite-trachyte, E. base of Sugarloaf peak, Raiatea.
3. I′. 5.1. (3)4. phlegrose-nordmarkose, nephelite-trachyte, Nutae, Taiarapu, Tahiti.
4. I′. 5.1. ′4. nordmarkose, nephelite-trachyte, Mount Tapioi, Raiatea.
5. I′. 5.1. ′4. nordmarkose, nephelite-trachyte, S. W. base of Mauratapu, Huahine.
6. I′. 5.1(2). 3–4. phlegrose-nordmarkose, nephelite-trachyte, Point Riri, Taiarapu, Tahiti.
7. I′. (5)6.1′. ′4. nordmarkose-miaskose, phonolite, Vaitia, Tautira valley, Taiarapu.
8. ′II. 5.1(2). 3. monzonose-ilmenose, nephelite-trachyte, Papetoai valley, Moorea.
9. (I)II. ′5.2. 3′. pulaskose-monzonase, latite, Road, 1 km. E. of Papetoai, Moorea.
10. (I)II. 5.2. 4. larvikose-akerose, kohalaite, Second spur W. of Mt. Tapioi, Raiatea.

Nos. 1, 2, 4, 5, 6, 7, 9, 10 by H. W. Foote; No. 3 by H. S. Washington; No. 8 by E. W. Morley.

TABLE OF CHEMICAL ANALYSES AND NORMS OF LAVA FROM SOUTH PACIFIC ISLANDS

	11	12	13	14	15	16	17	18	19	20
SiO_2	52.11	50.11	50.73	47.60	46.55	46.96	46.01	47.55	44.74	42.46
Al_2O_3	20.04	18.91	17.22	13.35	10.75	11.00	11.49	14.53	16.74	13.85
Fe_2O_3	3.27	4.55	3.62	2.83	2.66	2.22	2.27	2.23	3.70	5.21
FeO	2.15	2.51	3.74	8.02	9.49	9.42	10.17	7.53	8.53	7.58
MgO	1.50	2.49	2.72	10.86	13.39	14.21	12.72	7.01	4.80	7.76
CaO	3.90	4.70	5.66	9.47	8.72	9.46	9.50	11.13	9.88	11.28
Na_2O	5.72	7.47	7.92	3.00	2.76	1.64	1.82	2.14	4.42	3.67
K_2O	5.30	4.29	3.89	1.82	1.56	1.40	1.38	1.84	1.14	2.34
H_2O+	2.84	0.69	0.36	0.43	0.87	0.61	1.10	1.68	1.12	0.65
H_2O-	0.30	0.78	0.12	0.17	0.51	0.05	0.33	0.57	0.33	0.07
TiO_2	1.90	1.97	1.91	2.65	2.54	2.77	2.90	3.24	3.68	3.64
ZrO_2		0.01	0.00							
CO_2		0.02	0.16							
P_2O_5	0.40	0.55	0.76	0.33	0.36	0.38	0.36	0.49	0.70	0.90
Cl		0.12	0.28							
F		0.13	0.14							
S		0.23	0.29							
Cr_2O_3	0.00	0.01	0.00	0.06	0.09	0.08	0.11	0.01	tr.	0.05
MnO	0.14	0.65	0.35	0.13	0.16	0.16	0.18	0.13	0.19	0.19
BaO		0.08	0.18							
SrO		0.10	0.22							
	99.57	100.37	100.27	100.27	100.41	100.36	100.34	100.08	99.97	99.65

Norms

	11	12	13	14	15	16	17	18	19	20
or	31.14	25.58	22.80	10.56	9.45	8.34	8.34	10.56	6.67	13.90
ab	28.30	22.01	24.10	18.86	17.82	13.62	15.20	17.82	21.48	3.67
an	13.34	5.28	0.28	17.79	12.23	18.63	19.18	24.74	22.52	14.46
ne	10.79	22.15	23.00	3.41	3.12				8.52	14.77
di	2.59	11.66	17.17	21.75	22.49	20.41	19.65	21.69	17.83	28.66
wo			0.58							
hy						9.74	5.78	8.14		
ol	1.82	0.56		17.72	24.27	19.35	20.88	4.16	7.41	7.07
mt	1.86	4.41	5.34	4.41	4.18	3.48	3.25	3.25	5.34	7.66
il	3.65	3.80	3.65	5.17	4.86	5.32	5.47	6.08	6.99	6.84
hm	2.08	1.60								
ap	1.01	1.34	2.02	0.67	1.01	1.01	1.34	1.34	1.68	2.02
etc	3.14	2.07	1.35	0.60	1.38	0.66	1.54	2.26	1.45	0.77
	99.72	100.46	100.29	100.94	100.81	100.56	100.63	100.04	99.89	99.82

11. (I)II. (5)6. 2. 3(4). essexose-borolanose, tautirite Beach, Tautira, Taiarapu, H. W. Foote.
12. II. 6. 1(2) 4. essexose-lardalose, haüynophyre, Faurahi valley, Mataia, Tahiti, E. W. Morley.
13. II. 6'. 1. 4. lardalose, haüpnophyre, Ururoa valley, Tahiti, E. W. Morley.
14. III. 5'. 3. 4. camptonose, dolerite, Dike, Rei Point, Tahaa, H. W. Foote.
15. III', 5'. '3. 4. camptonose, basalt, Central mountain, Bora Bora, H. W. Foote.
16. III'. 5. 3(4). (3)4. kentallenose-camptonose, basalt, South of Fare, Huahine, H. W. Foote.
17. III'. 5, 3(4). '4. auvergnose-camptonose, basalt, Mountain between bays, Moorea, H. W. Foote.
18. III. 5. (3)4. (3)4. camptonose-auvergnose, basalt, S. W. base of Mauratapu, Huahine, H. W. Foote.
19. (II)III. (5)6. 3. 4(5). camptonose-limburgose, basalt, Upper flow, Point Tapahi, Tahiti, H. W. Foote.
20. III. 6'. (2)3. 4. monchiquose-limburgose, theralite, Vaitipihia, Tautira, Taiarapu, H. W. Foote.

TABLE OF CHEMICAL ANALYSES AND NORMS OF LAVA FROM SOUTH PACIFIC ISLANDS

	21	22	23	24	25	26	27	28	29	30
SiO_2	41.70	37.59	43.86	43.45	42.78	43.05	43.46	43.29	40.28	39.68
Al_2O_3	14.55	15.18	7.42	7.21	9.26	9.21	8.69	9.10	10.68	7.35
Fe_2O_3	6.11	3.98	2.41	3.24	2.00	1.90	4.17	6.88	5.23	7.81
FeO	7.83	6.50	12.39	9.92	10.82	10.21	8.58	7.25	8.37	8.60
MgO	7.80	8.49	21.53	23.97	12.44	13.41	18.82	16.21	10.19	14.29
CaO	12.39	12.73	7.96	6.85	14.37	10.15	10.41	10.11	17.23	15.78
Na_2O	2.92	2.80	1.16	1.28	2.89	3.58	1.02	1.44	0.47	0.82
K_2O	1.80	2.38	0.66	0.68	1.24	0.73	0.54	0.88	0.41	0.47
H_2O+	0.73	2.44	0.45	0.70	0.40	0.87	1.01	1.48	2.08	0.39
H_2O-	0.01	0.13	0.18	0.36	0.05	0.90	0.42	0.54	0.39	0.01
TiO_2	3.46	5.01	2.10	2.03	2.66	3.00	2.34	2.84	4.82	4.50
ZrO_2					0.02	0.00				
CO_2					0.01	0.10				
P_2O_5	0.63	2.29	0.19	0.24	0.50	2.21	0.28	0.32	0.27	0.17
Cl					0.07	0.13				
F					0.03	0.03				
S					0.24	0.24				
Cr_2O_3	0.03	0.00	0.08	0.17	0.12	0.10	0.17	0.11	0.02	0.09
MnO	0.22	0.13	0.18	0.17	0.43	0.36	0.15	0.14	0.13	0.21
BaO					0.04	0.05				
SrO					0.06	0.00				
	100.18	99.65	100.57	100.27	100.43	100.23	100.06	100.59	100.57	100.17

Norms

	21	22	23	24	25	26	27	28	29	30
or	10.56	6.67	3.89	3.89		4.45	2.78	5.56	0.56	
ab	3.67		9.96	10.48		16.77	8.38	12.05		
an	21.41	21.68	10.29	12.23	8.62	7.23	17.79	15.57	26.13	15.29
ne	11.36	12.78			13.35	7.38			1.99	3.69
lc		6.10			5.67				1.31	2.18
di	28.84	21.01	22.67	17.82	42.61	23.42	25.29	25.59	45.32	43.46
wo										2.42
hp			2.72	1.16			6.06	4.50		
ol	6.89	8.39	41.55	44.79	17.92	25.15	26.89	19.21	5.40	12.47
cs					1.89					
mt	8.82	5.80	3.48	4.64	3.25	3.02	6.03	10.21	7.66	11.37
il	6.69	9.58	3.95	3.80	5.17	5.78	4.41	5.32	9.12	8.51
ap	1.34	5.38	0.34	0.34	1.34	5.04	0.67	0.67	0.67	0.34
etc	0.77	2.58	0.71	1.23	0.92	2.32	1.60	2.02	2.49	0.49
	100.35	99.97	99.56	100.38	100.74	100.56	99.90	100.70	100.65	100.22

21. III. 6. 3. 4. limburgose, theralite, Maroto river, Papenoo valley, Tahiti, H. W. Foote.
22. III. (6)7. 3. (3)4. limburgose-etindose, theralite, Vaitipihia, Tautira, Taiarapu, H. W. Foote.
23. IV. 1(2). 3(4). (1)2. 2. wehrlose-rossweinose, limburgite, Papetoai valley, Moorea, H. W. Foote.
24. IV. 1(2). 4. (1)2. 2. limburgite, Spur E. of Sugar-loaf peak, Raiatea, H. W. Foote.
25. IV. 1(2). 2′. 2′. 2′. montrealose-palisadose, limburgite, Fautaua valley, above falls, Tahiti, E. W. Morley.
26. (III)IV. (1)2. 2. 3. 2. 2. rossweinose-uvaldose, limburgite, Fautaua valley, trail above falls, Tahiti, E. W. Morley.
27. IV. ′2, 3, ′2. 2. uvaldose, limburgite, on road W. of Point Tapahi, Tahiti, H. W. Foote.
28. ′IV. 2. (2)3. ′2. 2. uvaldose limburgite, Spur N. of bay, W. side of Raiatea, H. W. Foote.
29. IV. 2. 1(2). 2(3). 2. brandbergose-yamaskose, augitic vein, Tautira valley, Taiarapu, H. W. Foote.
30. IV. 2. 2. 3′. 2. paolose, peridotite, Vaitipihia, Tautira valley, H. W. Foote.

tephritic trachyte, or to Lacroix's nephelite-micromonzonite. It is proposed to call this particular variety of rock, *tautirite*, from the valley in which it occurs.

On Tahiti, in the valley of Ururoa on the north coast, there is a variety of haüynophyre with microscopic haüynites, analysis, 13, which is chemically somewhat like the haüynophyres analyzed and described by Lacroix, and by Marshall. The microcrystalline groundmass consists of alkalic feldspar, augite and magnetite, with small phenocrysts of haüynite, augite and very few brown hornblendes. A similar haüynophyre occurs sparingly in the valley of Faurahi, on the southwest side of Tahiti. Its chemical analysis is no. 12. These rocks are scarce on Tahiti.

On Raiatea the heavy sheet of trachytic lava, which tops the ridge and spurs of the northern half of the island, varies somewhat in composition in different places. On the second spur west of Mount Tapioi it has numerous phenocrysts of feldspar, with fewer of mica and paramorphs of hornblende. The chemical analysis, no. 10, shows it is kohalaite, or oligoclase-trachyte. A non-porphyritic gray lava on Moorea is unusual in appearance for rocks of this region. Its chemical analysis, no. 9, shows it is latite, an aphanitic lava phase of monzonite. The corresponding monzonite occurs as a variety of the syenitic rocks in the core of the Tahitian volcano.

THE LAW CONTROLLING THE QUANTITY AND RATE OF REGENERATION

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Communicated, March 18, 1918

1. It is well known that isolated pieces of a plant or a lower animal may regenerate into a whole organism again. In order to replace the current vague speculations concerning this phenomenon by a scientific theory in the sense of the physicist, quantitative experiments are required. The writer has for the past two years made such experiments which have led to a remarkably simple law controlling the quantity of regeneration in an isolated piece of an organism. This law can be expressed as follows: The mass of tissue regenerated by an isolated piece of an organism is under equal conditions and in equal time in direct proportion to the mass of growth material contained in the sap (or blood) of the isolated piece. The experiments on which this law is based were carried out on an organism unusually favorable for investigations of this kind, namely, the plant *Bryophyllum calycinum* (known to many laymen as the Bermuda 'life plant'). When leaves of this plant are isolated from the stem they will regenerate shoots in some or many of their notches. If a piece of